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Fair share and social efficiency: a mechanism in which peers decide on the payoff division*

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Abstract

We propose and experimentally test a mechanism for a class of principal-agent problems in which agents can observe each others' efforts. In this mechanism each player costlessly assigns a share of the pie to each of the other players, after observing their contributions, and the final distribution is determined by these assignments. We show that cooperation can be achieved under this simple mechanism and, in a controlled laboratory experiment, we find that players use a proportional rule to reward others in most cases and that the players' contributions improve substantially and almost immediately with 80% of players contributing fully.

Keywords: mechanism design, experimental economics, fairness, distributive justice

JEL Classification: D62, H41, C79, C90, D63,

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1 Introduction

It is well known that for a wide class of principal-agent problems, the principal may find it costly to observe the actions or characteristics of agents. The classical team production literature recommends appointing a manager to divide the surplus (Alchian and Demsetz (1972); Holmström (1982)). However, if the surplus division is not made proportional to effort, an agent who feels under-compensated for her deserved share, may end up reducing her effort. Often in reality, while it may be costly for a principal to observe the actions of agents, it is possible that agents themselves are in a position to observe each others' actions. In this context, we consider a simple mechanism in which fair-minded agents are not only able to monitor each other, but also in positions to determine each other's payoffs. The mechanism we propose takes the form of a two stage game. In the first stage, each player chooses some effort level and in the second stage, after having observed each others' effort, each player proposes a fraction of the total surplus to be received by each of the remaining players. A player's final share depends on the other players' allocation toward her.

The interesting feature of such a mechanism is that how a player allocates shares in the second stage does not affect her own payoff. Therefore, fair-minded players are able to reward or punish their peers based on the first stage observed actions. Our behavioural assumption relates to the notion of fairness. While some theoretical literature on fairness has focused on equality (Fehr and Schmidt, 1999), a growing empirical literature appeals to other fairness criteria to justify unequal allocations, e.g., Adams (1965); Konow(1996, 2000, 2009); Gächter and Riedl (2006); Cappelen et al. (2007); Shaw (2013); Cappelen et al. (2013).[1] For example, in one of Konow's (2000) experiments, when asked to divide some surplus among a group of participants, a disinterested third party almost always allocated the surplus proportional to each group member's contribution to that surplus. The main contribution of this paper is to propose a simple mechanism that relies on the notion of fairness whereby agents reward others based on their merit, and that achieves social efficiency by eliminating the free-rider problem in experimental settings.

We label our mechanism the "Galbraith Mechanism" as the idea is inspired by John Kenneth Galbraith who in an aside in The Great Crash described a bonus sharing scheme used by the National City Bank (now Citibank) in the U.S in the 1920s where each officer

[1]The literature distinguishes between two type of allocators: stakeholders and spectators. Stakeholders can allocate stakes to themselves in the allocation decisions, a self-biased fairness view may occur (Konow, 2000). Spectators allocate between the others, therefore are more likely to maintain impartiality. In our mechanism, all allocators are spectators because their allocation decisions do not affect their own earnings.

would sign a ballot giving an estimated share towards each of the other eligible officers, himself/herself excluded. The average of these shares would guide the final allocation of the bonus to each of the officers. This profit-sharing scheme can be applied to many economic problems including games with positive externalities and principle-agents problems in which the principal needs to decide on the distribution of some common resource among the agents.[2]

In their seminal paper, Fehr and Gächter (2000) show that players exhibit a strong social preference to "punish" those who free-ride on the group production. Such a social preference helps to achieve social efficiency. Their result not only remains robust in many subsequent studies, but has also lead to some theoretical studies that incorporate behavioral considerations in utility functions (see Chaudhuri (2010) for a recent survey). However, it has been argued that from a welfare view point costly punishments might be inefficient as players need to destroy some of their own payoffs in order to punish others. Moreover, the practicality of implementing "punishment" in organizations remains unclear. The mechanism we propose is based on an endogenous payoff allocation in which players can freely decide on some fraction of the counter-players payoff. Players are free to punish, to reward, or even always allocate randomly to the remaining players while no costs are incurred by the players in the allocation exercise.

Our research is also related to endogenous mechanisms used to solve social dilemma problems. For example, Andreoni and Varian (1999) studied a mechanism where players can agree on a pre-play contract before the prisoner's dilemma game. However, their mechanism does not perform well when tested in laboratory settings. There are other mechanisms that perform better in the laboratory, for example, Falkinger et al. (2000); Masuda et al. (2014) and Stoddard et al. (2014). But these mechanisms demand either an enforcement instituion, or require the intervention of a third party. Instead, our mechanism can achieve the full cooperation result in a decentralized manner, with no external allocator required.

The remainder of the paper is organized as follows. Section 2 presents our mechanism and its assumptions. Section 3 describes the experimental design. Experimental results are discussed in section 4 and section 5 concludes.

[2]Another example which fits our mechanism well is the division of marks in university level group assignments. There professors typically observe only the final output but wish to award marks based on individual students' inputs. In such a situation, our mechanism can be described by a two stage game in which students choose how much effort to exert in the first stage and in the second stage after observing each others effort, each student proposes a fraction of the total marks (sum of marks given to all students in the group) to be given to each of the remaining students in his group.

2 Galbraith Mechanism (Theory)

We focus on the following simple model of team production. There are three players. Each player, indexed i, has an initial endowment of $\bar{e}$ and takes an observable action $e_i \in E_i = (0, ..., \bar{e})$. The players' actions determine a joint monetary outcome $\Pi = \beta(e_1 + e_2 + e_3)$, which must be allocated among the players. Let q_i stand for player i's share of the outcome Π, and each player i's payoff function is $\pi_i = \bar{e} - e_i + q_i\Pi$.

We now describes the determination of each player's share from the final outcome, q_i, in the Galbraith Mechanism. Let a_{ij} denote the fraction of Π proposed by player i to player j such that $a_{ii} = 0$, $a_{ij} \in [0, 1]$ $\forall i \neq j$ and $a_{ij} + a_{ik} = 1$. In other words, each player proposes a fraction of Π to be received by each of the other players. The final share q_i that each player i receives is $q_i = \frac{a_{ji}+a_{ki}}{3}$.

At this point, there is no prediction of how a player i will divide $\frac{\Pi}{3}$ between the other two players. In fact, they can allocate all $\frac{\Pi}{3}$ to one player, or divide equally between the group members, or even allocate randomly. To give some guidance of plausible allocation rules based on previous research on distributive justice,[3] we construct the following allocation rule in the context of the Galbraith Mechanism:

$$a^*_{ij} = \begin{cases} \frac{e_j}{e_j+e_k} & \text{if } e_j + e_k \neq 0 \\ \frac{1}{2} & \text{if } e_j + e_k = 0 \end{cases} \tag{1}$$

Proposition 1 (Galbraith Mechanism with Fair Allocation)**.** *For the three player case, suppose each player i allocates using the proportional rule outlined in Equation 1 in the second stage. Then the strategy profile in which $e_i = \bar{e}$ for each i is the dominant strategy Nash equilibrium in the first stage if and only if $\beta > \frac{3}{2}$.*

The proof of Proposition 1 is relegated to Appendix A. Note that this proposition can be easily extended to the n player case: $e_i = \bar{e}$ for each i is the dominant strategy Nash equilibrium in the first stage if and only if $\beta > \frac{n}{n-1}$.

[3] According to the equity theory (Adams, 1965), the fair proportion of player j's share of the total outcome should be $q_i = \frac{e_i}{e_i+e_j+e_k}$. Under the Galbraith Mechanism, perfect implementation of the proportional rule cannot always be achieved. This is because the highest fraction one player can get is two-thirds. Suppose player i deserves more than two-thirds under the exact proportional rule, i.e., $q_i = \frac{e_i}{e_i+e_j+e_k} > \frac{2}{3}$, then this cannot be implemented under the Galbraith Mechanism. However, the allocation rule described in equation (1) is equivalent to what has be described as the accountability principle in Konow (1996) and the Liberal fairness rule in Cappelen et al. (2007) from the spectator's point of view.

Motivated by Proposition 1, we now investigate whether the experimental findings will support our theory. In particular, we run experiments to try to answer the following two questions: first, how do people allocate in the second stage, and second, how do people contribute in the first stage.

3 Experimental Design and Procedure

We ran 14 experimental sessions at the Centre for Decision Research and Experimental Economics (CeDEx) in Nottingham in February 2015. The experiments have two treatments: one control treatment and one Galbraith Mechanism treatment (see Table 1). In total, 126 university students from various fields of study took part, with 9 participants in each session. Participants were allowed to participate in only one session. Those participants were drawn from the CeDEx subject pool, which was managed using the Online Recruitment System for Economic Experiments (ORSEE; Greiner (2015)). The experiment was programmed in z-Tree (Fischbacher, 2007). Each session lasted about 60 minutes and the average payment was 8.34 (equivalent to $12.93 or €11.65 at the time of the experiment).

Upon arrival, participants were asked to randomly draw a number from a bag and they were seated in a partitioned computer terminal according to that number. The experimental instructions were provided to each participant in written form and were read aloud to the subjects (the instructions can be found in Appendix B). Only after all participants had given the correct quiz answers with respect to the instructions, the experiment started. Each experiment contained 20 rounds of decision making tasks that can be divided into two segments of ten rounds (see Table 1). The instructions for the second ten-round segment were distributed only after the completion of the first ten rounds. In each round, the computer program draws three participants to form a group, and the group composition reshuffles every round.[4]

In the first ten rounds, equal sharing rules were applied to all participants.[5] We used

[4]The matching of the three-person group was pre-determined by the computer software. Specifically, each participant would never be in the same group with the two other participants twice during the whole experiment. We randomized the display of players' contribution details on the screen in each round; in this way, players were not able to track the identities of other players over rounds.

[5]The equal sharing rule, where the final production is equally divided among group members, is equivalent to the voluntary contribution mechanism. To compare with other studies (e.g., Andreoni and Varian (1999); Fehr and Gächter (2000); Falkinger et al. (2000)), we introduce our mechanism after ten rounds of the equal sharing rule.

Table 1: Experiment Design

	Treatment		No. of	No. of
	Round1-10	**Round11-20**	**subjects**	**sessions**
Experiment	Equal Share	Galbraith Mechanism	90	10
Control	Equal Share	Equal Share	36	4
Total:			216	14

Notes: In each round, a group of three players will be matched by random-matching protocols . Each player chooses a contribution e_i, and the production function is $\Pi(e_1, e_2, e_3) = 1.8(e_1 + e_2 + e_3)$. In the equal share treatment, player i's payoff function is $\pi_i = 10 - e_i + 0.6(e_1 + e_2 + e_3)$. In the Galbraith Mechanism, each player i allocates $0.6(e_1 + e_2 + e_3)$ between the other two players so that $a_{ij} + a_{ik} = 0.6(e_1 + e_2 + e_3)$. Player i's own payoff is $\pi_i = 10 - e_i + a_{ji} + a_{ki}$.

neutral terminology in the experiment and the contribution question formulated on the computer screen was "Tokens you want to add to the Group Fund:__." In each round, players chose an integer from 0 to 10. The integer hence represented the contribution, e_i, chosen by the player i. The production function was $\Pi(e_1, e_2, e_3) = 1.8(e_1 + e_2 + e_3)$, and each player's payoff function was $\pi_i = 10 - e_i + \frac{1}{3}\Pi$. At the end of each round, players were informed about all group members' payoffs and were reminded that they would not be in the same group again.

In round 11-20, there were two decision stages in each round of the Galbraith Mechanism. The first stage decision was the same as in the Equal Share treatment, that is, each player voluntarily chose an integer from 0 to 10. In the second stage, the computer screen displayed each group members contribution decisions in the first stage and the value of the group fund. Each players task was to divide $\frac{1}{3}\Pi$ or $0.6(e_1 + e_2 + e_3)$ between the other two group members with a resolution of 0.1. In other words, player i allocated $\tilde{a}_{ij}$ to player j and allocated the remaining $\tilde{a}_{ik} = \frac{\Pi}{3} - \tilde{a}_{ij}$ to player k. Player i's share of the group production was determined by the allocation decisions by player j and player k. Their payoff function was $\pi_i = 10 - e_i + \tilde{a}_{ji} + \tilde{a}_{ki}$.[6] In the control treatment, players simply repeated the same decision task as in round 1-10 for another ten rounds.

[6]In section 2, a_{ij} is defined as the proportion player i allocates to player j, and $a_{ij} + a_{ik} = 1$. To calculate player's final profit, a_{ij} would be normalized by dividing by the group number and multiplying by the joint profit, i.e., $\pi_i = 10 - e_i + \frac{a_{ji}+a_{ki}}{3}\Pi$. To make our experiment cognitively easy, we asked participants to divide $\frac{\Pi}{3}$ ex ante. In other words, we set $\tilde{a}_{ij} = \frac{\Pi}{3}a_{ij}$.

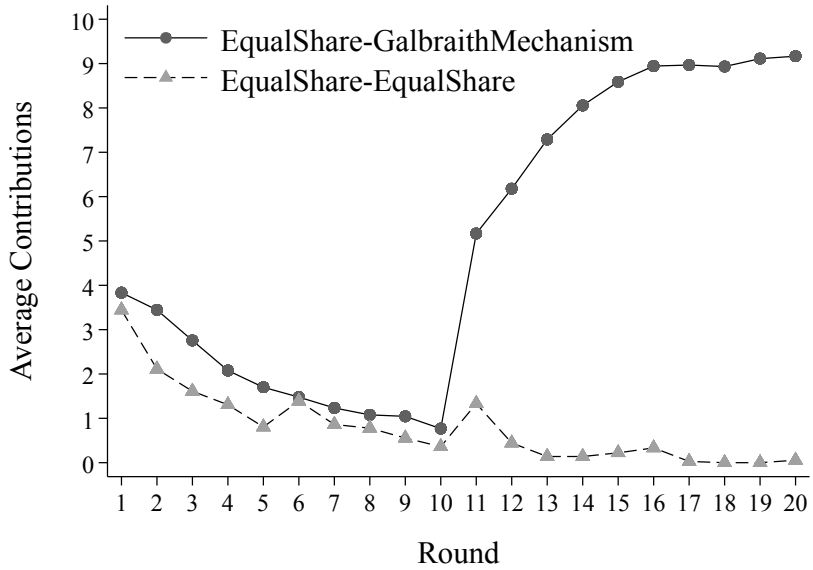


Figure 1: Time-path of the Average Contribution by Treatment

4 Experimental Results

We split the analysis into three parts. Section 4.1 looks at the difference of the contribution decisions across treatments. Section 4.2 analyzes the participants' allocation decisions, and Section 4.3 studies how allocation choices affect the players' contribution decisions.

4.1 Contributions

Figure 1 displays the time-path of the average contributions over all 20 iterations for each treatment. The first ten rounds are when the equal sharing rule is used. We observe a steady decline in the level of contributions over time. Participants start with an average contribution level of 3.72 and end up with 0.65 in round 10. This finding is consistent with results from other studies in which group compositions are reshuffled every round (e.g.,Croson (1996); Fischbacher and Gächter (2010)).

At the beginning of round 11, we introduce the Galbraith Mechanism in 10 out of 14 sessions. This introduction triggers a dramatic increase in the contribution level. Specifically, 43.3% of players increase their contributions with the Galbraith Mechanism in round 11, but only 24.3% of players raises their contributions in the control treatment (binomial test, $z = 1.99$, $p = 0.02$, one-sided). Furthermore, the contribution level in the Galbraith Mechanism

in round 11 (mean=5.17) is significantly higher than the contribution in the control treatment (mean=1.33, Mann-Whitney test on session's average contribution, $z = 2.82$, $p < 0.01$, one-sided). Over the ten rounds with the Galbraith Mechanism, the average contribution is 8.0 and the final round contributions reach an average of 9.16. In the last round, most players (82.8%) contribute fully to the group fund, and 21 out of 30 three-player groups coordinate on the (10,10,10) equilibrium. On the other hand, almost all players (35 out of 36) in the control treatment have zero contribution in later rounds. Appendix C1 shows the average contributions across rounds and sessions.

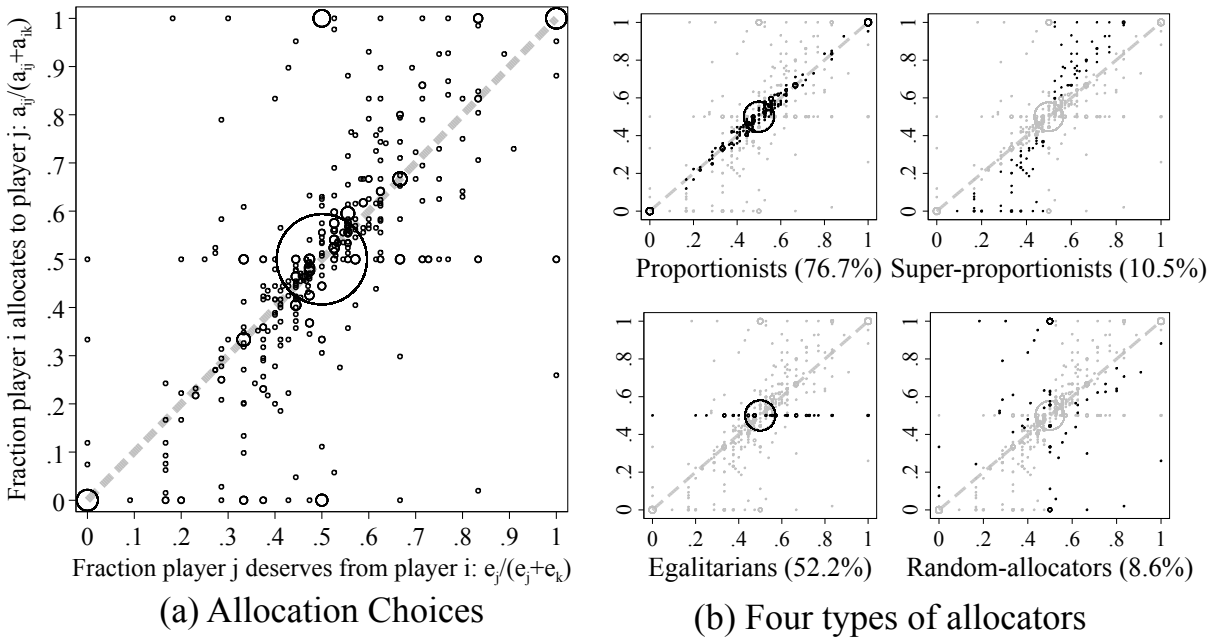
Result 1. *Sessions with the Galbraith Mechanism observe a 80% cooperative rate while sessions with the equal share allocation rule fail to promote cooperation.*

4.2 Allocation Decisions

In this section, we investigate players' allocation decisions. Recall that for each round in the Galbraith Mechanism treatment, participants need to decide on how to allocate between the other two group members. The allocation must sum up to one third of the group fund, that is, $\tilde{a}_{ij} + \tilde{a}_{ik} \equiv \frac{\Pi}{3}$. In the following analysis, we only consider each player i's allocation to player j (randomly determined from the data), $\tilde{a}_{ij}$, because the allocation to each player k is automatically determined by $\tilde{a}_{ik} \equiv \frac{\Pi}{3} - \tilde{a}_{ij}$.

We represent all players' allocation choices in Figure 2a. The horizontal axis indicates the fraction player j deserves from player i, that is, $\frac{e_j}{e_j+e_k}$, and the vertical axis shows the actual fraction i allocates to player j, that is, $\frac{\tilde{a}_{ij}}{\tilde{a}_{ij}+\tilde{a}_{ik}}$. The size of the circle indicates the relative frequency of the observation. More than half of the observations (55.4%) fall exactly on the 45-degree line where $\frac{e_j}{e_j+e_k} = \frac{\tilde{a}_{ij}}{\tilde{a}_{ij}+\tilde{a}_{ik}}$. This means a large number of players allocate proportionally according to the other's entitlement. Indeed, the fractional allocations (mean of $\frac{\tilde{a}_{ij}}{\tilde{a}_{ij}+\tilde{a}_{ik}}$ equals 0.503) are very close to players' entitlements (mean of $\frac{e_j}{e_j+e_k}$ equals 0.502, t-test, $p = 0.75$, two sided).

Table 2 presents additional support for the use of the proportional rule from a random effects regression. The dependent variable is the fraction player i allocates to player j, and the independent variables is the fraction player j deserves from player i. The proportional rule predicts the coefficient of $\frac{e_j}{e_j+e_k}$ equals 1 and the intercept term equals zero. The estimates of these parameters are consistent with the hypothesis: the estimated coefficient of $\frac{e_j}{e_j+e_k}$, 0.919, is different from zero ($p < 0.01$) and not significantly different from 1(F-test, $\chi^2(1) = 1.43$,



Notes: Figure 2(a) includes 900 allocation decisions. The size of the circle indicates the relative frequency of the observation. Observations lie on the 45-degree line means player i use the proportional rule to allocate.

Figure 2: Allocation Decisions in Galbraith Mechanism

$p = 0.23$). The intercept, meaning the fraction player i allocates to player j when player j deserves zero, is not significantly different from zero ($p = 0.20$).

Result 2. *In most cases, players allocate according to the others' contributions.*

Besides these observations gathered on the 45-degree line, a closer visual investigation in Figure 2a reveals some other interesting patterns of the allocation choices. We categorize allocators into four different types as shown in Figure 2b.[7]

Proportionists Those are the players who allocate based on others merit. Overall, 55.4% of the observations fall exactly on the 45 degree line in Figure 2a, i.e., $\frac{\tilde{a}_{ij}}{\tilde{a}_{ij}+\tilde{a}_{ik}} = \frac{e_j}{e_j+e_k}$. Because our software only allows the input with a resolution of 0.1 and that $\frac{e_j}{e_j+e_k}$ may not always be a fraction of ten, we relax the equality condition and use the following condition instead. Define player i as a Proportionist when $\mid \frac{\tilde{a}_{ij}}{\tilde{a}_{ij}+\tilde{a}_{ik}} - \frac{e_j}{e_j+e_k} \mid \leq 0.05$ (see the category highlighted as Proportionists in Figure 2b). In 76.7% of the instances, players allocate like proportionists.

[7] A depper investigation of which players use the non-proportional rules is provided by probit regressions in Appendix C2. For these players, the higher their contribution the more likely they are to choose the super-proportional rule and the less likely to use the egalitarian rule or to make a random allocation.

	Dep. Variable: Fraction Player i Allocate to Player j		
	(1)	(2)	(3)
Fraction j Deserved: β_1	0.919***	0.844***	0.889***
	(0.068)	(0.121)	(0.068)
Intercept: β_0	0.044	0.138	-0.006
	(0.034)	(0.082)	(0.079)
#Data Used	All	$e_j > e_i$	$e_j < e_i$
#Observations	900	219	214
#Clusters	10	10	10
$H_0 : \beta_1 = 1$	$\chi^2(1) = 1.43$	$\chi^2(1) = 1.66$	$\chi^2(1) = 2.63$
	$(p = 0.231)$	$(p = 0.197)$	$(p = 0.105)$

Notes: The table reports the regression results for random-effects model with the standard error clustered at the session level. *** indicates significance at 1% level. Period dummies are controlled for in the regression: the estimated coefficients are between -0.028 to 0.021, and they are not significantly different from zero at conventional significance levels.

Table 2: Allocation Choice: Random Effects

Egalitarians These are the players who allocate the $\frac{1}{3}\Pi$ equally to the other two group members. In 52.2% of the observations, players allocate using the egalitarian rule (see the category highlighted as Egalitarians in Figure 2b). Note that proportionists and egalitarians are not mutually exclusive. For example, if the other two players contribute the same amount, both the proportional and the egalitarian rules predict an equal allocation. This is not a rare case especially in later rounds (rounds 16-20), where full contributions of all three players are frequently observed. In total, there are 48.2% of the observations that can be classified as both using proportional and egalitarian rules. However, when conditioning on the inequality of contributions between the other two players, only less than 5% of players choose to allocate equally.

Super-proportionists If player j contributes less than player k, player i, under the "super-proportionists" category, rewards player j with less than what a proportionist would give. The other player, player k, is consequently over-compensated. 10.5% of the observations falls under this rule (see the category highlighted as Super-proportionists in Figure 2b). In other words, super-proportionists tend to "punish" players who contribute less than the others and over-compensate players who contribute more than the others. Note that the possibility allowed by the Galbraith Mechanism to "punish" other players is different from the "punishment mechanism" in Fehr and Gächter

(2000). Under their setting, players can choose to incur a cost to destroy part of the other players' payoff. With the Galbraith Mechanism, however, players bear no cost to "punish" others. Moreover, if a super-proportionist "punishes" one player, the other group member will be over-compensated automatically. The overall welfare, hence, remains the same.

Random-allocators The remaining 8.6% of observations that cannot be captured by any of the three rules listed above, we label as random allocators (see the last panel of Figure 2b).

4.3 Allocation received and contribution decisions

So far, we have established the empirical support for Proposition 1. That is, most players do allocate using the proportional rule and the contribution rate is high. In this section, we want to check the causal relationship between these two events. Specifically, we look at the effect of the reward players receive in the previous round on their contribution decisions in the current round. Note that the reward a player receives in a certain round is the aggregate result of her two group members' allocation rules. We categorize them in a similar way where we define different types of allocators in the previous section.[8,9] Most players are treated by the proportional rule under most circumstances (77.5%), and in about 47.7% of the cases all three group members are rewarded with equal shares. Note that, in 45% of the total observations, these two rules overlap. This occurs because all three players contribute equally; hence, they deserve an equal share. To study the effect of each individual allocation rule received on a player's next round contribution, we exclude these observations in the following analysis.[10] In this restricted dataset (n=425), in 59.2% of the circumstances, players are treated by the proportional rule, and in 4.8% of the cases, they are treated by the egalitarian rule. In 12.5% of the incidences, players are under-compensated, or punished, for contributing

[8]The fair allocation player i "should" receive under the Galbraith Mechanism is $q_i^F = \frac{1}{3}(\frac{e_i}{e_i+e_j} + \frac{e_i}{e_i+e_k})$. When $e_i + e_j = 0$ or $e_i + e_k = 0$, $q_i^F = \frac{1}{6}$ and when $e_i + e_j + e_k = 0$, $q_i^F = \frac{1}{3}$, although these later two cases never showed up in our dataset. The actual fraction player i receives is $q_i = \frac{a_{ji}+a_{ki}}{3}$. Player i is treated by the proportional rule if $|q_i - q_i^F| \leq 0.05$. Player i is treated by the egalitarian rule if $q_i = \frac{1}{3}$. When $q_i < q_i^F < \frac{1}{3}$ and $q_i^F - q_i > 0.05$, we say player i is being under-compensated, or punished. When $q_i > q_i^F > \frac{1}{3}$ and $q_i - q_i^F > 0.05$, we say player i is being over-compensated. If player i's received allocations cannot be classified by the rules outlined before, we say player i is treated by a random allocation.

[9]Note that the fair allocation i should receive in the liberal sense is $q_i^* = \frac{e_i}{e_i+e_j+e_k}$; it can be different to the fair amount player i receives under the Galbraith Mechanism $q_i^F = \frac{1}{3}(\frac{e_i}{e_i+e_j} + \frac{e_i}{e_i+e_k})$.

[10]We also conduct a parametric test in Appendix C3 with and without the data exclusions. The results are consistent with the following analysis.

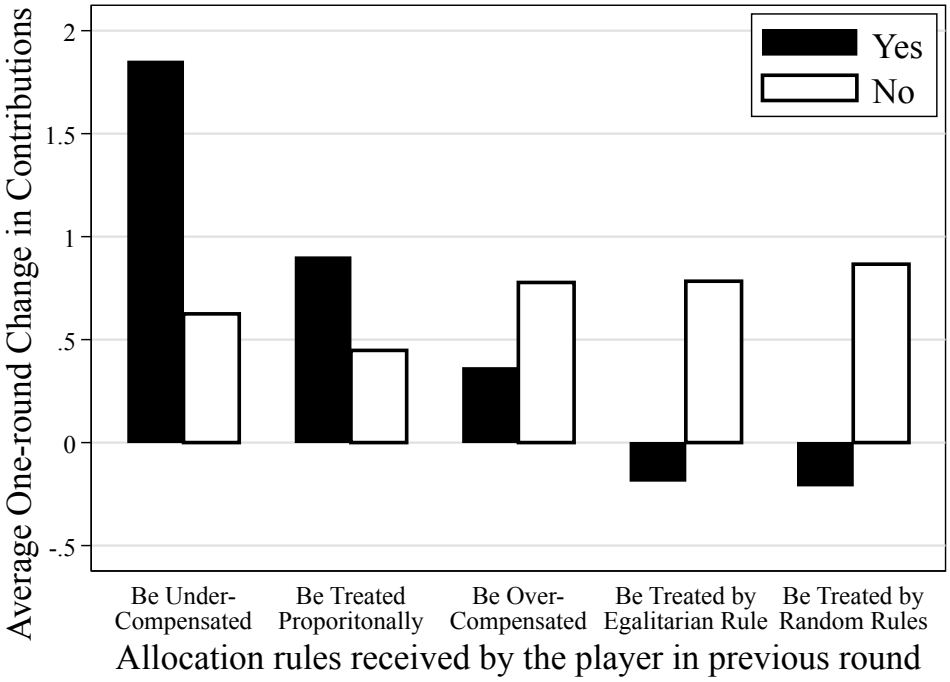
less than their group members; in 13.8% of the cases, players are over-compensated for contributing more than their group members. These latter two categories correspond to the "super-proportional" types of players as discussed in the previous section. In the remaining 9.7% of incidences, players are treated by a random allocation.

Figure 3 presents the one-round change in the contributions according to whether or not the player is treated by a certain allocation rule from the previous round. We want to discover whether there is difference in the one round change based on the allocations players received from the last round. For example, the first two bars in the figure show that players who are being "punished" increase their contributions in the next round (mean = 1.85) more than those players who are *not* being punished (mean = 0.62, Mann-Whitney test,[11] $z = 3.07$, $p < 0.01$, two-sided). While receiving a proportional allocation increases players' contribution compare to those players who are treated by other rules (mean difference = 0.45; Mann-Whitney test, $z = 1.58$, $p = 0.11$, two-sided), being over-compensated seem to decrease their contributions (mean difference = -0.41; Mann-Whitney test, $z = 3.80$, $p < 0.01$, two-sided).[12] Players who receive an equal allocation despite their unequal contributions lower their next round contributions (mean difference = -0.97; Mann-Whitney test, $z = 3.02$, $p < 0.01$, two-sided). Last, being treated by a random rule has a strong negative effect on players' contribution in the subsequent round; on average, those players contribute 1.07 less than players who are treated by alternative rules (Mann-Whitney test, $z = 4.19$, $p < 0.01$, two-sided).

Result 3. *How players are rewarded in the allocation stage affects their contribution decisions in the subsequent round: those players who are treated by the proportional rule or who are under-compensated by their group members increase their contributions; on the other hand, those players who are treated by the egalitarian rule or random rules, or who are over-compensated by their group members, decrease their contributions in the next round.*

[11] To cope with the repeated measure problem, the following Mann-Whitney tests are all clustered at the individual level.

[12] Players who are being overcompensated have an average contribution of 8.58, and 68.3% of these players have full contributions. Therefore, it is difficult for over-compensation to stimulate further increases in contribution. Previous studies also found that the effect of punishment is stronger than the effect of reward (e.g. Andreoni et al., 2003; Sefton et al., 2007).



Notes: (1) The figure is based on 415 decisions from round 12 to round 20 classified by the allocation rule they received in the previous round. We exclude the observations where all three players contribute equally, as both proportional rule and egalitarian rule yield the same prediction. (2) "Yes" means the set of players who are treated by a certain allocation rule and "No" means those players who are *not* treated by that particular rule.

Figure 3: The response of contributions according to each allocation rules received

5 Conclusion

Our goal in this study was to propose and experimentally test a mechanism in which peers can decide on others' payoffs after a joint production stage. We test the mechanism in a economic laboratory with groups of three players. We found that the majority of participants allocate according to what the other players deserve from the group. Consequently, almost full contribution in the production stage in the later rounds of the experiment are observed. We interpret our result as a successful attempt to improve social efficiency by combining social preference with the right form of institution.

In the traditional mechanism design literature, self-interest is an important assumption. Recent developments in behavioural and experimental studies show various degrees of other-regarding preferences (Fehr and Schmidt (1999); Charness and Rabin (2002); Cox et al. (2007); Benabou and Tirole (2011)). Although a complete replacement of pure self-interest with various forms of "social preferences" may lead to unreliable results, to design an effective institution, richer behavioural assumptions such as fairness and other moral standards are undeniably valuable. In our study, we demonstrate that a small intrinsic concern for justice,

when utilized by an appropriate social institution, has significant success in overcoming the free-rider problem in team production and improving social efficiency. In our view, such a mechanism inherently relying on behavioural assumptions deserves further study, and may have great potential in practical applications.

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Appendices

Appendix A. Proof of Proposition 1

Proof. In the first stage, $e_i = \bar{e}$ is a dominant strategy if and only if $\pi_i(\bar{e}, e_{-i}) > \pi_i(e_i, e_{-i})$, $\forall e_{-i}$. It suffices to prove $\pi_i(e_i + \Delta e_i, e_{-i}) > \pi_i(e_i, e_{-i})$,$\forall e_{-i}$ where $\Delta e_i > 0$. We consider the following three cases.

1. Suppose $e_j = e_k = 0$. If player i chooses to contribute, $e_i > 0$, both player j and player k will give player i 1 in the allocation stage. Therefore, $a_{ji} + a_{ki} = 2$ and $\pi_i(e_i, e_{-i}) = \bar{e} - e_i + \frac{2}{3}\beta e_i$. If player i chooses not to contribute, then $\pi_i(0, e_{-i}) = \bar{e}$. Note, $\beta > \frac{3}{2}$ is a sufficient condition to make $\pi_i(e_i, e_{-i}) > \pi_i(0, e_{-i})$. Furthermore, when $e_i > 0$, we have $\pi_i(e_i + \Delta e_i, e_{-i}) = \bar{e} + (\frac{2}{3}\beta - 1)(e_i + \Delta e_i)$. Therefore, $\pi_i(e_i + \Delta e_i, e_{-i}) > \pi_i(e_i, e_{-i})$ if and only if $\beta > \frac{3}{2}$.

2. Suppose $e_j = 0$ and $e_k > 0$, or, $e_j > 0$ and $e_k = 0$. That is, except for player i, there is only one player who contributes. We only consider the case where player k contributes and player j does not; the other case would be similar. Now if player i chooses to contribute, $e_i > 0$, player k would give player i $a_{ki} = 1$ and player j would give player i $\frac{e_i}{e_i+e_k}$. Therefore $a_{ki} + a_{ji} = 1 + \frac{e_i}{e_i+e_k}$ and $\pi_i(e_i, e_{-i}) = \bar{e} - e_i + \frac{\beta}{3}(e_i + e_k)(1 + \frac{e_i}{e_i+e_k})$. Next, suppose that player i does not contribute, that is, $e_i = 0$. Then only player k will give him $\frac{1}{2}$ and player j will give him zero. Therefore, $a_{ki} + a_{ji} = 1/2$ and $\pi_i(0, e_{-i}) = \bar{e} + \frac{\beta}{6}e_k$. Note, $\beta > \frac{3}{2}$ is a sufficient condition to make $\pi_i(e_i, e_{-i}) > \pi_i(0, e_{-i})$. Furthermore, when $e_i > 0$, we have $\pi_i(e_i + \Delta e_i, e_{-i}) - \pi_i(e_i, e_{-i}) = (\frac{2}{3}\beta - 1)\Delta e_i$. Therefore, $\pi_i(e_i + \Delta e_i, e_{-i}) > \pi_i(e_i, e_{-i})$ if and only if $\beta > \frac{3}{2}$.

3. Suppose $e_j > 0$ and $e_k > 0$. That is, both player j and player k contribute. If player i chooses to contribute, $e_i > 0$, player j will give him $\frac{e_i}{e_i+e_k}$ and player k will give him $\frac{e_i}{e_i+e_j}$. Therefore, $a_{ji} + a_{ki} = \frac{e_i}{e_i+e_k} + \frac{e_i}{e_i+e_j}$ and $\pi_i(e_i, e_{-i}) = \bar{e} - e_i + \frac{\beta}{3}(e_i + e_j + e_k)(\frac{e_i}{e_i+e_k} + \frac{e_i}{e_i+e_j})$. If player i chooses not to contribute, then $\pi_i(0, e_{-i}) = \bar{e}$. We next re-write player i's payoff function $\pi_i(e_i, e_{-i})$ for ease of calculation, and then prove $\pi_i(e_i + \Delta e_i, e_{-i}) - \pi_i(e_i, e_{-i}) > 0$:

$$
\begin{aligned}
\pi_i(e_i, e_{-i}) &= \bar{e} - e_i + \frac{\beta}{3}(e_i + e_j + e_k)(\frac{e_i}{e_i + e_j} + \frac{e_i}{e_i + e_k}) \\
&= \bar{e} - e_i + \frac{\beta}{3}(e_i + \frac{e_i e_k}{e_i + e_j} + e_i + \frac{e_i e_j}{e_i + e_k}) \\
&= \bar{e} - e_i + \frac{2\beta}{3} e_i + \frac{\beta}{3} e_i (\frac{e_k}{e_i + e_j} + \frac{e_j}{e_i + e_k}) \\
&= \bar{e} + (\frac{2\beta}{3} - 1) e_i + \frac{\beta}{3}(\frac{e_k}{1 + \frac{e_j}{e_i}} + \frac{e_j}{1 + \frac{e_k}{e_i}}) \qquad (2)
\end{aligned}
$$

Thus,

$$
\begin{aligned}
&\pi_i(e_i + \Delta e_i, e_{-i}) - \pi_i(e_i, e_{-i}) \\
&= (\frac{2\beta}{3} - 1)\Delta e_i + \frac{\beta}{3}(\frac{e_k}{1 + \frac{e_j}{e_i + \Delta e_i}} + \frac{e_j}{1 + \frac{e_k}{e_i + \Delta e_i}}) - \frac{\beta}{3}(\frac{e_k}{1 + \frac{e_j}{e_i}} + \frac{e_j}{1 + \frac{e_k}{e_i}}) \\
&= (\frac{2\beta}{3} - 1)\Delta e_i + \frac{\beta}{3}(\frac{e_k}{1 + \frac{e_j}{e_i + \Delta e_i}} - \frac{e_k}{1 + \frac{e_j}{e_i}} + \frac{e_j}{1 + \frac{e_k}{e_i + \Delta e_i}} - \frac{e_j}{1 + \frac{e_k}{e_i}}) \qquad (3)
\end{aligned}
$$

The first bracket in Equation 3 is greater than zero if and only if $\beta > \frac{3}{2}$; the second bracket is always greater than zero when $\Delta e_i > 0$.

□

Appendix B. Experimental Instructions

We present the experimental instructions for the experiment treatment (Sequence 1 is for the equal sharing rules and sequence 2 is for the Galbraith Mechanism). Participants receive printed copies of the instructions and the experimenter read it aloud in each session. Sequence 2 instruction is distributed only after the completion of Part 1 decisions. The accompanied quiz questions and z-Tree program are available upon request.

SEQUENCE 1 (Decision round 1-10)

Welcome! You are taking part in a decision making experiment. Now that the experiment has begun, we ask that you do not talk. The instructions are simple. If you follow them carefully and make good decisions, you can earn a considerable amount of money. If you have questions after we finish reading the instructions, please raise your hand and one of the experimenters will approach you and answer your questions in private. This experiment consists of two sequences of decision rounds. Each sequence contains ten rounds. In each round, you will be in a group with two other people, but you will not know which of the other two people in this room are in your group. The people in your group will change from round to round, and in particular you will never be matched with the same set of two other participants twice during the whole experiment.

The decisions made by you and the other people in your group will determine your earnings in that round. Your earnings in this experiment are expressed in experimental currency units, which we will refer to as ECUs. At the end of the experiment you will be paid in cash using a conversion rate of 1 of every 30 ECUs of earnings from the experiment. Under no circumstance will we expose your identity. In other words, your decisions and earnings will remain anonymous with us. This set of instructions details Sequence 1. An additional set of instructions detailing sequence 2 will be provided after sequence 1 is completed.

Sequence 1 consists of ten decision rounds. At the beginning of each round, you will be randomly allocated a participant identification letter, either A, B, or C. (Thus, your identification letter may change from round to round).

<u>Decision Task in Each Round</u> Each individual begins each round with an endowment of 10 tokens in their Individual Fund. Tokens in Individual Fund worth 1 ECU each. Each three-person group begins with a Group Fund of 0 ECUs each round. Each person will decide independently and privately whether or not to contribute any of his/her tokens from his/her own Individual Fund into the Group Fund. Tokens in the Group Fund worth 1.8 ECU each. Each person can contribute up to a maximum of 10 tokens to the Group Fund. Decisions must be made in whole tokens. That is, each person can add 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 tokens to the Group Fund.

<u>Feedback and Earnings</u> After all participants have made their decisions for the round,

the computer will tabulate the results. ECUs in Group Fund = 1.8 × (Sum of tokens in the Group Fund). ECUs in the Group Fund will be divided equally among all individuals in the group. That is, each group member will receive one-third of ECUs in the Group Fund. Your earning in one round equals ECUs in your Individual Fund plus one-third of ECUs in the Group Fund. Your Earnings =ECUs in Individual Fund + $\frac{1}{3}$ ECUs in Group Fund. At the end of each round, you will receive information on your Group Fund earnings and your total earnings for that round. You will also be informed of all group members' contribution to the Group Fund and their earnings in ECUs. Total Earnings for the experiment will be the sum of the earnings in all rounds of the experiment. This completes the instructions for Sequence 1.Before we begin the experiment, to make sure that every participant understands the instructions, please answer several review questions on your screen.

SEQUENCE 2 (Decision round 11-20)

Sequence 2 consists of ten decision rounds. In each round, you will be in a group with two other people, but you will not know which of the other two people in this room are in your group. The people in your group will change from round to round, and in particular you will never be matched with the same set of two other participants twice during the whole experiment. At the beginning of each round, you will be randomly allocated a participant identification letter, either A, B, or C. (Thus, your identification letter may change from round to round).

Decision Task in Each Round Each individual begins each round with an endowment of 10 tokens in their Individual Fund. Tokens in Individual Fund worth 1 ECU each. Each decision round will have two phases.

Phase 1: Decision Choice Decision choice will be the same as in Sequence 1. Each three-person group begins with a Group Fund of 0 ECUs each round. Each person will decide independently and privately whether or not to contribute any of his/her tokens from his/her own Individual Fund into the Group Fund. Tokens in Group Fund worth 1.8 ECU each. Each person can contribute up to a maximum of 10 tokens to the Group Fund. Decisions must be made in whole tokens. That is, each person can add 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 tokens to the Group Fund.

Phase 2: Allocation Choice After all individuals have made their decisions in Phase 1, you will be informed of the other two group members' contribution to the Group Fund, the total number of tokens and ECUs in the Group Fund. ECUs in Group Fund = 1.8 × (Sum of tokens in the Group Fund). You decide how to allocate one-third of the ECUs in the Group Fund between the other two group members.In other words, the sum of your allocation between the other two group members will be one-third of ECUs in the Group Fund. Each person can only divide one-third of ECUs in the Group Fund for the other two group members, their own share of the Group Fund will be determined by the allocation decisions of the other two group members. Specifically, 1) Person A will divide one-third of

ECUs in the Group Fund between Person B and Person C. 2) Person B will divide one-third of ECUs in the Group Fund between Person A and Person C. 3) Person C will divide one-third of ECUs in the Group Fund between Person A and Person B. You may change your choice as often as you like. But once you click Submit, the decision will be final. Click the calculator button on the lower-right corner if you need the assistance of calculation.

Feedback and Earnings After all individuals have made their decisions for the round, the computer will tabulate the results. A person's share of the Group Fund will be determined at the end of phase 2. His/her earnings from Group Fund will be the sum of ECUs that the other two group members allocate towards him/her. Your earnings in a round will equal ECUs in your Individual Fund plus ECUs the other two group members allocated to you (i.e., your share of ECUs in the Group Fund). At the end of each round, you will receive information on your Group Fund earnings and your total earnings for that round. You will also be informed of all group members' contribution to the Group Fund, their allocation decisions in phase 2 and their earnings in ECUs for that round. Total Earnings for the experiment will be the sum of the earnings in all rounds of the experiment. This completes the instructions. Before we resume the experiment, to make sure that every participant understands the instructions, please answer several review questions on your screen.

Appendix C. Further statistical analysis

C.1. Descriptive Statistics

This appendix provides additional statistics on players' contributions in round 11-20. Table 3 shows the average contributions and the standarded deviation across rounds. Columns 6-7 report the Mann-Whiteney test clustered at the session level with the null hypothesis of equal contributions. Figure 4 outlines the average contributions across sessions.

Round	Galbraith Mechanism		Equal Share		Mann-Whitney test	
	Mean	S.D.	Mean	S.D.	z statistic	p value
11	5.17	3.56	1.33	2.98	2.82	0.005
12	6.18	3.22	0.44	1.18	2.82	0.005
13	7.29	2.98	0.14	0.54	2.83	0.005
14	8.06	2.75	0.14	0.68	2.83	0.005
15	8.59	2.28	0.22	1.05	2.84	0.004
16	8.94	2.14	0.33	1.69	2.84	0.004
17	8.97	2.45	0.03	0.17	2.91	0.004
18	8.93	2.44	0.00	0.00	2.93	0.003
19	9.11	2.23	0.00	0.00	2.93	0.003
20	9.17	2.20	0.06	0.33	2.91	0.004

Table 3: Summary of contributions in round 11-20

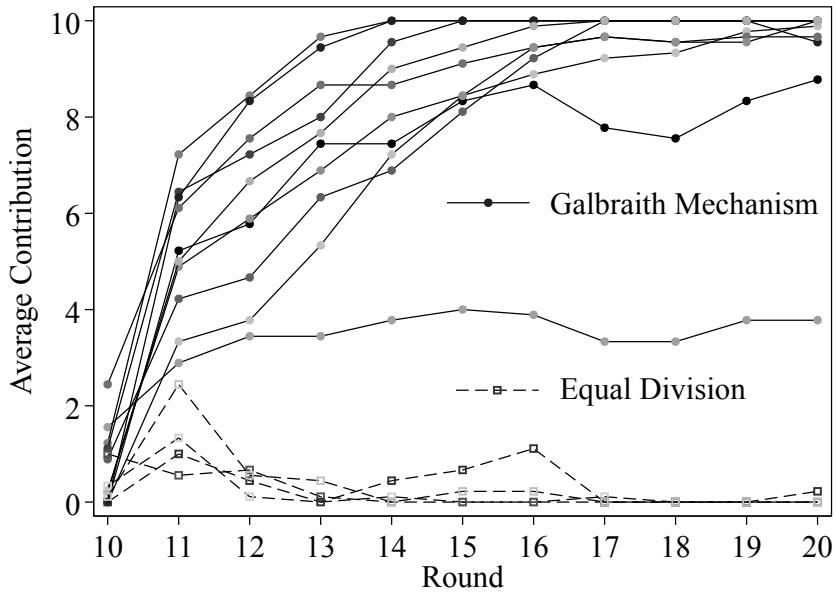

Figure 4: Average contributions in each the 14 nine-participant session (independent group)

C.2. What determines players' allocation rules?

To understand what may help to explain players' different allocation rules outlined in section 4.2, we use probit regressions of the form:

$$Pr\{A_{ij,r} = 1\} = \Lambda(\alpha_1 Contribution_{i,r} + \alpha_2 OtherContribution_{i,r} + \alpha_3 \frac{e_j}{e_j + e_k} + \alpha_4 Round_i + \varepsilon_i)$$

where $A_{ij,r} = 1$ if the subject chooses a certain allocation rule to allocate to player j in round r, and zero otherwise. We use the allocation rules defined in section 4.2 to classify $A_{ij,r}$. That is, in models (1)-(4), $A_{ij,r}$ indicates whether or not player i is using the proportional rule, the egalitarian rule, the super-proportional rule and random rules to allocate in round r, respectively. $Contribution_{i,r}$ is player i's own contribution in round r. The variable $OtherContribution_{i,r}$ is the average contribution of the other two group members in round r. The variable $\frac{e_j}{e_j+e_k}$ is the fraction player j deserves from player i and $\varepsilon_{i,r}$ is error term. We exclude observations where the proportional rule and the egalitarian rule predict the same outcome, because they do not help us to distinguish how players choose different rules.

	1 if player choose the allocation rule:			
Dependent Variables:	(1) Proportional	(2) Egalitarian	(3) Super-proportional	(4) Random
$Contribution_i$	0.060	-0.325***	0.135***	-0.079***
	[0.024]	[-0.016]	[0.037]	[-0.019]
	(0.038)	(0.029)***	(0.040)***	(0.011)***
$Others' Contribution_i$	-0.023	0.097**	-0.059	0.057
	[-0.009]	[0.005]	[-0.016]	[0.014]
	(0.021)	(0.037)**	(0.036)	(0.043)
Entitlement: $\frac{e_j}{e_j+e_k}$	-0.253	0.764	-0.172	0.147
	[-0.100]	[0.038]	[-0.046]	[0.035]
	(0.260)	(0.402)	(0.247)	(0.470)
$Round_i$	-0.038	0.056	-0.037	0.098
	[-0.015]	[0.003]	[-0.010]	[0.023]
	(0.042)	(0.038)	(0.046)	(0.052)
Constant	0.537	-1.587*	-0.834	-2.320*
	(0.575)	(0.694)*	(0.603)	(1.052)*
pseudo R^2	0.016	0.344	0.061	0.050
Number of observations	466	466	466	466

Notes: The table shows four Probit estimates of the propensity for players to choose allocation rules: 1) proportional rule, 2) egalitarian rule, 3) Super-proportional rule and 4) Random allocations, respectively. Standard errors clustered at the session level are reported in brackets and the implied average marginal effects are shown in parentheses below the coefficient estimates. *,** and *** denote, respectively, significance level at the 10%, 5% and 1% levels.

Table 4: The Determinants of Allocation Rules

Table 4 presents the estimated parameters for the model. (1) None of these variables has a significant role in explaining why players choose the proportional rule relative to the others. (2) The egalitarian rule tends to be chosen by low contributors, when others' contributions are high. (3) The super-proportional rule tends to be chosen by high contributors and (4) Random allocations tend to made by low contributors.

C.3. How allocations received affect players' decisions on contributions in the next round?

Figure 3 above graphically illustrates how a player is treated in the previous round affects her next round contribution. In this appendix we use regression analysis to investigate this relationship further. Our behavioural equation of the change in contribution for player i in round r, $\Delta e_{i,r}$ is given by:

$$\Delta e_{i,r} = \gamma_0 + \mathbf{B_{i,r-1}}\theta + \gamma_1 OtherContribution_{i,r-1} + \gamma_2 Round_i + \varepsilon_i$$

Here $\mathbf{B_{i,r-1}}$ is a set of dummy variables which indicate how the player was treated at the allocation stage in the previous round. Specifically, $B^{EGA}_{i,r-1}$, $B^{UNDERCOMP}_{i,r-1}$, $B^{OVERCOMP}_{i,r-1}$, $B^{RANDOM}_{i,r-1}$ are dummy variables indicating whether the player was treated by the egalitarian rule, was undercompensated, was overcompensated or was subject to a random allocation, respectively, in the previous round. Being treated by the proportional rule is taken as the base case. The variable $OtherContribution_{i,r-1}$ represents the average contribution of the other two members in the player's group in the previous round. This is intended as a proxy for the player's belief about the likely contributions of the other group members in the current round. The behavioural regulation of conditional cooperation (i.e. matching the other group members' contributions) is well documented in the literature (e.g. Fischbacher et al. (2001);Fischbacher and Gächter (2010)). $Round_i$ captures the time trend and $\varepsilon_{i,r}$ is an unobservable variable that is assumed to have mean zero and is uncorrelated with other explanatory variables. The estimation method is OLS with robust standard errors clustered at the session level.

Table 5 presents the estimated equations. The result in Columns 2 and 3 confirm that, relative to the proportional rule, egalitarian or random treatment in the previous round results in a lower increase (or larger decrease) in contribution in the current round. The estimates in Column 2 exclude the "dual" observations (i.e. those that meet both the proportional and egalitarian criteria), and there we find that players who were punished in the previous round seem to increase their current contribution (the estimated coefficient is 0.741, two sided $p = 0.11$) and those who were over-compensated tend to decrease their current contribution (the estimated coefficient is -0.489, two sided $p = 0.09$). These results are strengthened when we include the dual observations under the egalitarian dummy in Column 3. The estimated coefficient on $OtherContribution_{i,r-1}$ is consistently positive and significant indicating that a higher average contribution by the other group members in the previous round generates a larger increase (or smaller decrease) in a player's contribution

Dependent Variable:	One-round Change in Contribution		
Treated by the egalitarian rule	-0.935***	-0.788***	-0.947
	(0.125)	(0.0987)	(0.443)
Being under-compensated	0.741	0.749*	2.803***
	(0.421)	(0.275)	(0.309)
Being over-compensated	-0.489	-0.512**	0.270
	(0.253)	(0.111)	(0.340)
Treated by random allocations	-0.942***	-0.608	-0.686
	(0.177)	(0.320)	(0.387)
Others' average contribution	0.146**	0.143**	0.278**
	(0.0358)	(0.0324)	(0.0646)
Round	-0.175**	-0.168***	
	(0.0442)	(0.0256)	
Constant	2.545***	2.383***	-0.238
	(0.526)	(0.359)	(0.418)
Round used	12-20	12-20	12
Data Excluded	Yes	No	No
Observations	415	810	90
Adjusted R^2	0.168	0.184	0.257

Notes: All results are from OLS regression. Standard errors clustered on session level are reported in brackets. *,** and *** denote, respectively, significance level at the 10%, 5% and 1% levels. Column 2 excludes observations where all three players contribute equally.

Table 5: Determinants of One-Round Contribution Change

in the current round, regardless of treatment. Likewise the negative coefficient on *Round* indicates that the increase in contributions get smaller as the rounds progress, other things equal. This is consistent with the concavity of the plots in Figure 1. Finally, the last column reports the results based on observations from round 12 only, which is the first round in which the players receive feedback on the allocations made by the other group members. Noteworthy here is the magnitude of the estimated coefficient on $B_{i,r-1}^{UNDERCOMP}$ (two-sided $p < 0.01$), which suggests that, other things equal, players who are being "punished" (under-compensated) in round 11 increase their contributions dramatically (by an average of 2.8 out of 10 tokens) in round 12.